High-performance blade server optimized for virtualization

Product Guide
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IBM BladeCenter HS22V

Product Overview

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High density, high performance 2-socket blade server optimized for virtualization

Suggested uses: *Mainstream virtualization and memory-intensive HPC applications requiring high memory density, outstanding performance, and enhanced power efficiency.*

Today's data center environment is tougher than ever. You're looking to reduce IT cost, complexity, space requirements, energy consumption and heat output, while increasing flexibility, utilization and manageability through virtualization. Incorporating IBM **X-Architecture**™ features, the **IBM® BladeCenter® HS22V** blade server, combined with the various BladeCenter chassis, can help you accomplish all of these goals.

Reducing an entire server into as little as **.5U** of rack space (i.e., up to 14 servers in 7U) does *not* mean trading away features and capabilities for smaller size. Each HS22V blade server offers features comparable to many 1U rack-optimized full-featured servers: The HS22V supports up to **two** of the latest high-performance **6-core**/**4-core**/**2-core** Intel® Xeon® 5600 series and 5500 series processors. The Xeon processors are designed with up to **12MB** of shared cache and leading-edge memory performance (up to **1333MHz**, depending on processor model) to help provide the computing power you require to match your business needs and growth. The HS22V supports up to **288GB** of **registered** double data rate III (**DDR3**) **ECC** (Error Checking and Correcting) memory in **18** DIMM slots, with optional **Chipkill**™ protection[1], for high performance and reliability. Selected models are planned for **NEBS-3**/**ETSI-compliance**.

The HS22V supports **VMware vSphere Hypervisor** (formerly ESXi) preloaded on a standard USB flash drive. It operates in a diskless configuration, offers a smaller memory footprint, extremely high performance, and stronger security, making getting a system up and running in a virtualized environment faster and easier than ever before. The HS22V supports approximately **50% more** average virtual machines (VMs) than the HS22. With up to 288GB of memory, the HS22V is an outstanding choice for virtualization, in-memory databases, and memory-intensive enterprise applications.

An integrated **dual-port Gigabit Ethernet**[2] controller is standard, providing high-speed data transfers and offering **TOE** (TCP Offload Engine) support, **load-balancing** and **failover** capabilities. Via optional expansion cards, each blade can also connect to additional Ethernet, **10Gb Ethernet**, Converged Network Adapter (**CNA**), **SAS**, **Fibre Channel**, **iSCSI, InfiniBand**™, and other high-speed communication switches housed in the chassis. This blade is designed with **power management capability** to provide the maximum uptime possible for your systems. In extended thermal conditions or power brownouts, rather than shut down completely, or fail, the HS22V automatically reduces the processor frequency to maintain acceptable thermal and power levels.

All HS22V models offer impressive features at an equally impressive price, including up to **two 1.8-inch fixed solid-state drives (SSDs)** with **RAID-0**/**1** support, and one **internal USB flash drive** (for embedded hypervisor]. Additional direct-attach storage is available via the BladeCenter S chassis. Moreover, the HS22V is **optimized** for diskless operation, offering each blade server access to essentially unlimited external storage capacity via Fibre Channel, SAS, or iSCSI.

A single **BladeCenter E** or **BladeCenter H** chassis supports up to **14 hot-swappable** 30mm-wide HS22V blades in only **7U** (BladeCenter E) or **9U** (BladeCenter H) of rack space or up to **12** in the **12U BladeCenter HT** high-speed telecommunications chassis. In addition to the blade servers, these chassis also hold up to **4 switches** (BladeCenter E) or up to **10** (BladeCenter H) or **8 switches/bridges** (BladeCenter HT) internally. The **BladeCenter S**, designed for SMB and mid-market customers, takes integration and affordability to a new level, combining up to **12** hot-swap **SAS**/**SATA** HDDs (with optional SAS card) and up to **6 blade servers** and **4 switches**. Not only can this save significant data center space (and therefore the cost of floor space and rack hardware) compared to 1U servers, it also consolidates switches/bridges and cables for reduced

[1] Chipkill protection on the HS22V requires x4 DIMMs; Chipkill protection is *not* available with x8 DIMMs.
[2] Actual data transfer speed will vary and is often less than the maximum possible. Gigabit Ethernet transfer speed requires support on both system and server, and appropriate network infrastructure.

complexity and lower cabling costs, and it allows clients to manage everything in the solution as one. Using a BladeCenter E chassis, up to **84** HS22V servers (**168** processors) can be installed in one **industry-standard 42U** rack; but the value of BladeCenter extends far beyond high density data center environments.

The various BladeCenter chassis are designed to monitor environmental conditions in the chassis and each blade and send alerts to the administrator**.** Advanced standard features, such as **Active Memory™**, **Predictive Failure Analysis, light path diagnostics**, **hot-swap redundant hard disk drives**, **power supplies and blower modules** with **Calibrated Vectored Cooling™**; **IPMI 2.0** support, including **highly secure remote power control**; **text-console redirect over LAN**, next-generation BIOS (**UEFI**), an **Advanced Management Module** (upgradeable with a redundant AMM), **IBM Systems Director** management software including **IBM Systems Director Active Energy Manager™**. **Remote Deployment Manager** and **IBM ServerGuide™** help maintain system availability with increased uptime.

If you need highly manageable, high-performance virtualization in a space- or power-constrained environment, the HS22V is the ideal system.

Selling Features

Price/Performance

- There is an HS22V model to fit all budgets. The HS22V offers a choice of high-performance **6-core/4-core/2-core Xeon** processors with integrated memory controllers, clock rates from **1.6GHz** to **3.6GHz**, and from **3MB** to **12MB** of shared cache (processor-specific) of integrated Level 3 cache. Xeon 5600 series processors offer up to **60%** better performance[3] than the previous-generation 5500 series processors and up to **1,500%** better performance than the single-core processors of a few years ago that you may still be using.
- **Low-voltage processors** draw less energy and produce less waste heat than higher-voltage processors, thus helping to reduce data **center** energy costs. On a per-core basis, the standard **80W** processors are extremely economical, consuming as little as **13.33W** per core. Some low-voltage Xeon processors consume only**10W** per core (4-core **40W** or 6-core **60W**).
- Up to **288GB** of **registered DDR3** ECC memory operates at **800MHz** to **1333MHz** (depending on the system configuration), for high performance and wide memory bandwidth.
- Run **two DIMMs per memory channel** (2DPC) at **1333MHz** in specific 5600 series processor configurations
- **Embedded virtualization** (optional on all models) offers extremely high performance, enhanced security, and a zero-gigabyte HDD footprint. (In other words, no mechanical HDD to fail.)
- **Solid state drives** (SDDs) use only 2W of energy per drive, vs. **7-10W** for 2.5-inch HDDs. This is as much as **80%** less energy than a HDD would use (with a corresponding reduction in heat output).
- **Low -voltage 1.35 volt memory** draws up to **19%** less power than 1.5V DIMMs.
- Selected HS22V blade servers are planned for **NEBS3/ETSI-compliance** and feature long-life availability. These blades are ideal for telecom or Next Generation Network (NGN) applications such as IPTV, IP Multimedia Subsystem (IMS) and security.
- The **extremely high degree of integration** in the various BladeCenter chassis reduces the need for server components, replacing numerous fans, KVM and Ethernet cables, power supplies, external switches and other components with fewer *shared* hot-swap/redundant components in the BladeCenter chassis itself. This integration also can greatly **reduce** the amount of **power consumed** and **heat produced**, relative to an equivalent number of 1U servers. This can significantly reduce a data center power bill. The **reduced data center footprint** can also save on infrastructure cost.
- The midplanes used in all chassis provide **high-speed blade-to-blade, blade-to-switch-module and module-to-module communications** internally as well as externally. The midplanes used in the BladeCenter H and BladeCenter HT chassis provide **four 10Gb** data channels to each blade, and supports high-speed switch modules, including **4X InfiniBand** and **10Gb Ethernet**.
- The various BladeCenter chassis use **ultrahigh efficiency power supplies**. Many industry-standard servers use power supplies that are only **70-80% efficient** at converting power from AC wall current to the DC power used inside servers. BladeCenter power modules are up to **94% efficient** (and meet the **80 Plus® Platinum Standard**). This helps save even more money, as more of the power input you are paying for is used for processing, rather than released into the data center as waste heat that requires even more energy to cool.
- BladeCenter also **reduces the number of parts required** to run the system. Sharing fans, systems management, floppy devices and media means fewer parts to buy and maintain, and fewer items that can fail and bring the overall solution down.

Flexibility

The **HS22V** has the ability to grow with your application requirements, thanks to:

[3] Based on Intel measurements.

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- Up to **two multi-core** Xeon processors (up to **twelve** cores per server).
- A choice of processor speeds from **1.6** to **3.6GHz**, up to **12MB** of shared cache, and a choice of power draw from **40W** to **130W**.
- A choice of *memory* speeds from **800MHz** to **1066MHz** or **1333MHz**.
- Up to **288GB** of system memory in **18 DIMM slots.**
- Up to two internal **hot-swap 1.8**-inch solid state drives, and access to terabytes of external storage via the BladeCenter S chassis or **IBM System Storage**® SAN and NAS storage devices. SSDs consume only 10-20% of the energy required by 2.5-inch HDDs.
- **Two** Gigabit Ethernet ports standard, plus optional **2-port** or **4-port expansion cards** or a **BladeCenter PCI Express I/O Expansion Unit 3**. In addition, the various **BladeCenter chassis** offer a high degree of flexibility:
- A 30mm HS22V blade server can be upgraded, via the **PCI Express I/O Expansion Unit 3**. This expandability allows configurations that are **30mm** or **60mm** wide, with a variety of I/O options, depending on need.
- When installed in a BladeCenter H high-speed switch bay, the optional **Multi-Switch Interconnect Module** doubles the number of **Gigabit Ethernet** and **Fibre Channel** connections to every blade in the chassis (up to **8** or **12** ports, depending on the blade server).
- Xeon processor-based **HS22V** blades can be used in the same chassis as Intel processor-based **HC10**, **HS12**, **HS20**, **HS21**, **HS21 XM**, **HS22**, **HS40**, and **HX5** blades; AMD Opteron processor-based **LS20**, **LS21, LS22**, **LS41** and **LS42** blades; IBM PowerPC® processor-based **JS20**, **JS21,** and **JS22** blades; POWER6® processor-based **JS12**, **JS23,** and **JS43 Express** blades; POWER7® processor-based **PS700**, **PS701**, and **PS702** blades; Cell Broadband Engine™ processor-based **QS21**; and IBM PowerXCell™ processor-based **QS22** blades. Depending on the blade servers used, the various BladeCenter chassis support Microsoft® **Windows**®, **Linux**®, Novell **Netware**, IBM **AIX**® IBM i, and Sun **Solaris 10** operating systems in the same chassis.
- *Most HS/LS/JS/PS/QS blade servers ever released by IBM are supported in every BladeCenter chassis ever release*d, going back to 2002[4]. Every switch module released by IBM is equally compatible. (Ask HP and Dell how far back *their* compatibility goes.)
- A blade server has access to as many as **10 communication switches/bridges** in a **BladeCenter H** or **8** in a **BladeCenter HT** chassis. (Up to **4** switches in a BladeCenter E, S, or T chassis.) And the switches can be Ethernet, iSCSI, SAS, InfiniBand, Fibre Channel, or anything else designed and ServerProven® for BladeCenter use. Switches, bridges and interface cards are currently available from such vendors as Brocade, Cisco , Intel, QLogic, Voltaire, and others, in addition to IBM/BNT.

Manageability

- The HS22V blade server includes an **Integrated Management Module (IMM)** to monitor server availability, perform Predictive Failure Analysis, etc., and trigger IBM Systems Director alerts. The IMM performs the functions of both the Baseboard Management Controller (**BMC**) of earlier systems, and the **Remote Supervisor Adapter II**, as well as **remote presence/cKVM.**
- Each BladeCenter chassis includes an **Advanced Management Module** to provide additional systems management capabilities, including Web-based out-of-band control; virtual floppy and CD-ROM support; latest OS failure screen capture; LDAP and SSL support; and remote redirection of video, text, keyboard and mouse.
- Integrated industry-standard Unified Extensible Firmware Interface (**UEFI**) next-generation BIOS. New capabilities include:
  - Human readable event logs; no more beep codes
  - Complete setup solution by allowing adapter configuration function to be moved into UEFI
  - Complete out-of-band coverage by the Advance Settings Utility to simplify remote setup
- Integrated industry-standard **IPMI 2.0** support works with the IMM to alert IBM Systems Director to anomalous environmental factors, such as voltage and thermal conditions. It also supports **highly secure remote power control**.
- Integrated **Trusted Platform Module (TPM) 1.2** support.
- IBM **Systems Director Active Energy Manager**, an IBM-exclusive, is designed to take advantage of new system power management features, by monitoring *actual* power usage and providing power consumption capping features. More accurate power usage data helps with data center construction planning and the sizing of power and cooling needs, as well as allowing you to use available power more efficiently.
- The HS22V supports **remote presence**/**concurrent KVM (cKVM)** and **concurrent media (cMedia)**

[4] Some older chassis may require power module and management module upgrades. But the chassis itself, as well as fan/blower modules and other components, are fully compatible.

access by multiple administrators at once, via the IMM.

- IBM Systems Director is included for proactive systems management and works with both the blade's internal IMM and the chassis' management module. It comes with a portfolio of tools, including IBM Systems Director Active Energy Manager, Service and Support Manager, and others. In addition, IBM Systems Director offers extended systems management tools for additional server management and increased availability. When a problem is encountered, IBM Systems Director can issue administrator alerts via e-mail, pager, and other methods.

Availability and Serviceability

- BladeCenter chassis are designed for operation with **greatly reduced potential for single points of failure**. Most aspects of operation, from blade servers to communication modules, to management modules, to power and blower modules, are **hot-swappable**. The midplane connections are **redundant** and the other features can be made so, when used in pairs.
- HS22V blade servers support the use of **Chipkill-enabled ECC** (error checking and correcting) memory. Chipkill memory can be up to **16X** better than standard ECC memory at correcting some types of memory errors. This can help reduce downtime caused by memory errors. Optional **memory mirroring** and **memory sparing** offer additional redundancies.
- **Solid-state drives** offer up to *triple* the reliability (MTBF rates) of conventional SAS HDDs. This can lessen the need for redundant drives.
- **IPMI 2.0** supports highly secure remote system power on/off using data encryption. This allows an administrator to restart a server without having to visit it in person, saving travel time and getting the server back up and running quickly and securely.
- **Environmentally tuned blower modules** in the chassis adjust to compensate for changing thermal characteristics. At the lower speeds they draw less power and suffer less wear. Equally important in a crowded data center, temperature-controlled blowers produce less ambient noise in the data center than if they were constantly running at full speed.
- **Text and graphics console redirection** support allows the administrator to remotely view HS22V text and graphic messages over serial or LAN connections.
- A **standard three-year (parts and labor) limited onsite warranty**[5] affords you peace of mind and greater potential investment protection.

Right, Open, Easy, Green

You need to make IT decisions that will drive business success. You face management challenges and technological complexity such as space constraints, power and cooling limitations, heterogeneous environments and I/O connectivity issues. IBM brings together the widest choice of compatible chassis, blade servers, storage and networking offerings and solution providers in the industry to help you build an open and flexible IT environment. And regardless of the size of your business, you want to be up and running 24/7. With built-in redundancy, innovative power and cooling and the latest I/O and management tools, IBM BladeCenter is easy to own—so you can focus on your business demands and stay ahead of the competition.

The **RIGHT** choice, tailored to fit your diverse needs:

- It's flexible and modular. As needs evolve, a one-size-fits-all solution doesn't work.
  - Meet your needs with BladeCenter: everything from a high-performance data center to a small office with limited IT skills—IBM has you covered
  - Get flexibility with 5 compatible chassis and 5 blade types supporting multiple I/O fabrics, all managed from a common point
- It's robust and reliable, providing redundancy throughout and the information you need to keep your business up and running.
  - Provide redundancy for no single point of failure with IBM BladeCenter
  - Preserve application uptime with IBM Predictive Failure Analysis® and light path diagnostics
  - Make decisions based on accurate data for quick problem diagnosis with First Failure Data Capture

OPEN and innovative, for a flexible business foundation:

- It's comprehensive, providing broad, fast, and reliable networking and storage I/O with BladeCenter Open Fabric.
  - Match your data center needs and the appropriate interconnect using a common management point, and 5 I/O fabrics to choose from
  - Extract the most from your third-party management solutions by utilizing the BladeCenter Open

[5] For terms and conditions or copies of the IBM Statement of Limited Warranty, call 800-772-2227 in the U.S. In Canada call 800-426-2255. Telephone support may be subject to additional charges. For warranties including onsite labor, a technician is sent after IBM attempts to resolve the problem remotely. International warranty service is available in any country in which this product is sold.

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Fabric Manager

- It's collaborative, enabling you to harness the power of the industry to deliver innovation that matters.
  - Get flexibility from a myriad of solutions created by Blade.org members and industry leaders that have downloaded our open specification

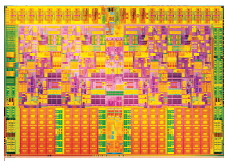
EASY to deploy, integrate and manage:

- It enables efficient integrated management, which allows you to minimize costs with the tools you need for effective management.
  - Automate OS installation and BIOS updates remotely with IBM Systems Director tools
  - Administer your blades at the chassis or rack level with the Advanced Management Module
  - Plug into your enterprise management software
- It enable deployment simplicity without tradeoffs by speeding the deployment of new hardware in minutes rather than days, using BladeCenter Open Fabric Manager
  - Get significantly faster deployment of servers and I/O than from rack solutions
  - Reduce costly downtime with integrated failover capability
  - Manage from a single point of control via the Advanced Management Module
  - Use with virtually all IBM switches, blades and chassis

GREEN today for a better tomorrow:

- It offers control via powerful tools that help you optimize your data center infrastructure so you can be responsive.
  - Understand your power requirements with IBM Power Configurator
  - Monitor, control and virtualize your power with IBM Systems Director Active Energy Manager
  - Reduce data center hot spots with the IBM Rear Door Heat eXchanger
  - Optimize and future-proof your data center with IBM Data Center Energy Efficiency services
- Our eco-friendly servers and services can help you be environmentally responsible.
- Become more energy efficient with IBM expertise

Key Features



Multicore Intel Xeon Processors

The HS22V supports up to **two** identical Xeon **5600** series or **5500** series processors (that is, the same clock rate and cache size and the same number of cores). Each processor contains a memory controller (meaning two in a two-processor system) for superior performance. (Some processor models are available only via CTO or special bid.)The choice of processors includes:

- **130W 6-core** Xeon **5600** series models **X5690** or **X5680** running at 3.46 or 3.33GHz (respectively), with impressive performance/watt (**21.67W** per core; **6.4GTps** QPI speed), **12MB** of L3 processor cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter E and BladeCenter T
- **130W** 4-core Xeon **5600** series model **X5677** running at 3.46GHz, with impressive *performance* (**32.5W** per core; **6.4GTps** QPI speed), **12MB** of L3 processor cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter E and BladeCenter T
- **95W 6-core** Xeon **5600** series models **X5675** or **X5670** running at 3.06 or 2.93GHz (respectively), with impressive performance/watt (**15.84W** per core; **6.4GTps** QPI speed), **12MB** of shared **L3** cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter T
- **95W** 4-core Xeon **5600** series model **X5672** running at 3.2GHz with reduced power draw and excellent performance/watt (only **23.75W** per core; **6.4GTps** QPI speed), **12MB** of L3 processor cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology and Hyper Threading Technology; supported in all BladeCenter chassis, except BladeCenter T
- **95W** 4-core Xeon **5600** series model **X5667** running at 3.06GHz, with excellent performance/watt (**23.75W** per core; **6.4GTps** QPI speed), **12MB** of shared **L3** cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter T; supported in all BladeCenter chassis, except BladeCenter T
- **80W 6-core** Xeon **5600** series model **E5649** running at 2.53GHz, with reduced power draw and impressive performance/watt (only **13.33W** per core; **5.86GTps** QPI speed), **12MB** of L3 processor cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology
- **130W** 4-core Xeon 5600 model **X5647** running at 2.93GHz with impressive *performance* (**32.5W** per core; **5.86GTps** QPI speed), **12MB** of L3 processor cache, **1066Hz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter E and BladeCenter T
- **60W 6-core** Xeon **5600** series model **L5640** at 2.26GHz, with low power draw and impressive

performance/watt (only **10W** per core; **5.86GTps** QPI speed), **12MB** of shared **L3** cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter T

- **80W** 4-core Xeon **5600** series models **E5640** or **E5620** at 2.66 or 2.4GHz (respectively), with reduced power draw and impressive performance/watt (only **20W** per core; **5.86GTps** QPI speed), **12MB** of shared **L3** cache, **1066MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter T
- **80W** 4-core Xeon **5600** series model **E5607** running at 2.26GHz, with reduced power draw and impressive performance/watt (**20W** per core; **4.8GTps** QPI speed), **8MB** of L3 processor cache, and **1066MHz** memory access
- **80W** 4-core Xeon **5600** series model **E5603** running at 1.6GHz, with reduced power draw and impressive performance/watt (**20W** per core; **4.8GTps** QPI speed), **8MB** or **4MB** (respectively) of L3 processor cache, and **1066MHz** memory access
- **80W** 4-core Xeon 5500 series model **E5507** at 2.26GHz, with reduced power draw and impressive performance/watt (only **20W** per core; **4.8GTps** QPI speed), **4MB** of shared **L3** cache, and **800MHz** memory access; supported in all BladeCenter chassis, except BladeCenter T
- **80W 2-core** Xeon 5500 series model **E5503** at 2.0GHz, with reduced power draw and impressive performance/watt (only **20W** per core; **4.8GTps** QPI speed), **4MB** of shared **L3** cache, and **800MHz** memory access; supported in all BladeCenter chassis, except BladeCenter T

Also available, via configure-to-order (CTO):

- **130W** 4-core Xeon **5600** series model **X5687** running at 3.6GHz, with impressive *performance* (**32.5W** per core; **6.4GTps** QPI speed), **12MB** of L3 processor cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter E and BladeCenter T
- **80W 6-core** Xeon **5600** series models **E5645** at 2.4GHz, with reduced power draw and impressive performance/watt (only **13.33W** per core; **5.86GTps** QPI speed), **12MB** of shared **L3** cache, **1333MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter T
- **60W 6-core** Xeon **5600** series **low-voltage** model **L5630** running at 2.0GHz, with low power draw and amazing performance/watt (only **10W** per core; **5.86GTps** QPI speed), **12MB** of L3 processor cache, and **1066MHz** memory access; supported in all BladeCenter chassis, except BladeCenter T
- **40W** 4-core Xeon **5600** series **low-voltage** model **L5609** running at 1.86GHz, with extremely low power draw and amazing performance/watt (only **10W** per core; **4.8GTps** QPI speed), **12MB** of L3 processor cache, and **1066MHz** memory access; supported in all BladeCenter chassis, except BladeCenter T
- **80W** 4-core Xeon **5600** series model **E5606** running at 2.13GHz, with reduced power draw and impressive performance/watt (**20W** per core; **4.8GTps** QPI speed), **8MB** of L3 processor cache, and **1066MHz** memory access; supported in all BladeCenter chassis, except BladeCenter T

Also available, via special bid:

- **40W** 4-core Xeon **5600** series **low-voltage** model **L5618** running at 1.86GHz, with extremely low power draw and amazing performance/watt (only **10W** per core; **5.86GTps** QPI speed), **12MB** of L3 processor cache, and **1066MHz** memory access, 2 threads per core, and Intel Turbo Boost technology; supported in all BladeCenter chassis, except BladeCenter T

Note: Because of the integrated memory controllers the former front-side bus (FSB) no longer exists.

With the Xeon 5600 series and 5500 series processors, Intel has diverged from its traditional Symmetric Multiprocessing (SMP) architecture to a Non-Uniform Memory Access (NUMA) architecture. The Xeon 5500 processors are connected through a serial coherency link called QuickPath Interconnect (QPI). QPI is capable of 6.4, 5.6 or 4.8 GTps (gigatransfers per second), depending on the processor model. Put another way, the 5600 series and 5500 series processors offer **3.6 times** the bandwidth of the previous 5400 series processors.

The **six-core Xeon** processors contain **six complete processor cores**. The processors also contain one shared cache. The shared cache is dynamically allocated among cores as needed. The six cores appear to software as six physical processors. Six-core processors offer considerably higher performance than a same-speed Xeon processor with four cores.

Turbo Boost Technology dynamically turns off unused processor cores and increases the clock speed of the cores in use, by up to two model frequencies. For example, a **2.93GHz 6-core X5670** processor with **3-6** cores active can run the cores at **3.2GHz**. With only **one** or **two** cores active, the same processor can run those cores at **3.33GHz**. Similarly, a **3.46GHz 4-core X5677** processor can run at **3.6GHz** or even **3.73GHz**. When the cores are needed again, they are dynamically turned back on and the processor frequency is adjusted accordingly.

Intelligent Power Capability powers individual processor elements on and off as needed, to reduce power draw.

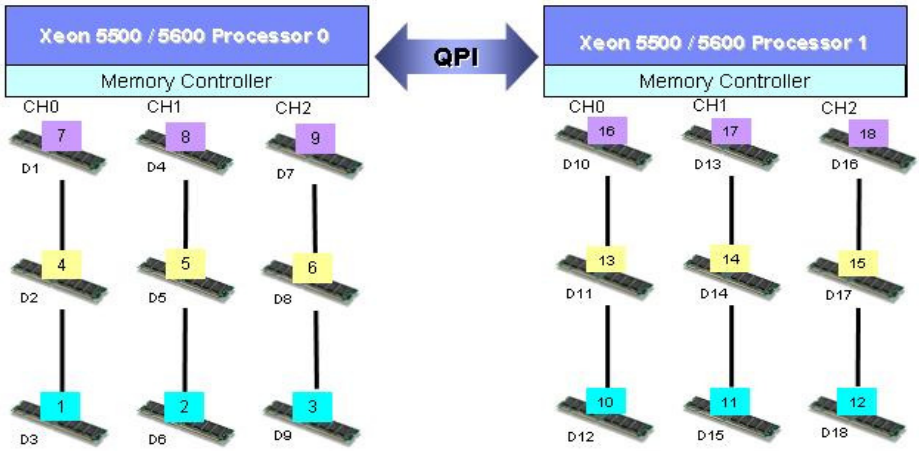
Execute Disable Bit functionality can help prevent certain classes of malicious buffer overflow attacks when combined with a supporting operating system.

Intel's **Virtualization Technology** (VT) integrates hardware-level virtualization hooks that allow operating system vendors to better utilize the hardware for virtualization workloads.

DDR3 Registered Memory with Active Memory Protection

The HS22V uses registered double data rate III (DDR3) VLP (very-low-profile) DIMMs and provides Active Memory features, including advanced **Chipkill** memory protection, for **up to 16X** better error correction than standard ECC memory. In addition to offering **triple the memory bandwidth** of registered or fully-buffered DDR2 memory, DDR3 memory also uses less energy. **1.8V** DDR2 memory already offered up to **37%** lower energy use than fully buffered memory. Now, a generation later, **1.5V** DDR3 memory is even more efficient, using **10-15% less energy** than DDR2 memory. For even greater efficiency, the HS22V also supports **1.35V** DDR3 memory, which uses up to **19%** less energy than 1.5V DDR3 DIMMs.

The HS22V supports up to **288GB** of memory in **eighteen** DIMM slots. Redesign in the architecture of the 5500 series and 5600 series processors bring radical changes in the way memory works in these servers. For example, the Xeon 5500 series and 5600 series processors **integrate the memory controller inside the processor**, resulting in two memory controllers in a two-socket system. Each memory controller has three memory channels. Depending on the type of memory, population of memory, and processor model, the memory may be clocked at **1333MHz**, **1066MHz** or **800MHz**.



1-16: DIMM population sequence: D1-D16: DIMM slot assignments

Note: If only one processor is installed, only the first nine DIMM slots can be used. Adding a second processor not only doubles the amount of memory available for use, but also doubles the number of memory controllers, thus doubling the system memory bandwidth. If you add a second processor, but no additional memory for the second processor, the second processor has to access the memory from the first processor "remotely," resulting in longer latencies and lower performance. The latency to access remote memory is almost *75% higher* than local memory access. So, the goal should be to always populate both processors with an equal number of DIMMs, with matching pairs spanning the processors.

The 1333MHz **E**56xx, **L**5640, and **X**56xx processor models support up to 1333MHz memory clock speed and 2 DIMMs per channel (2DPC) at 1333MHz with single-rank and dual-rank RDIMMs and UDIMMs running at 1.5V. Other 5600 series processors access memory at **1066MHz**. The **E550**x models support memory at 800MHz only.

Running memory at 1333MHz (where supported) versus 1066MHz offers up to **9%** better performance, while running memory at 1066MHz produces up to **28%** better performance than memory running at 800MHz.

Xeon 5600 series and 5500 series processors access memory with almost **50% lower latency** than the previous generation 5400 series processors. That can result in faster processing of latency-sensitive workloads.

This new processor design comes with some trade-offs in memory capacity, performance, and cost: For example, more lower-cost/lower-capacity DIMMs mean lower memory speed. Alternatively, fewer higher-capacity DIMMs cost more but offer higher performance.

Regardless of memory *speed*, the Xeon 5600 series and 5500 series platform represents a significant improvement in memory *bandwidth* over the previous Xeon 5400 platform. At

1333MHz, the improvement is almost **500%** over the previous generation. This huge improvement is mainly due to the dual integrated memory controllers and faster DDR3 1333MHz memory. Throughput at 800MHz is **25 gigabytes per second** (GBps); at 1066MHz it's **32GBps**; and at 1333MHz it's **35GBps**. This improvement translates into improved application performance and scalability.

Memory interleaving refers to how physical memory is interleaved across the physical DIMMs. A balanced system provides the best interleaving. A Xeon 5600 processor-based system is balanced when all memory channels for a socket have the same amount of memory.

In the case of HS22V, which has a balanced DIMM layout, it is easy to balance the system for all three memory frequencies. The recommended DIMM population is shown below, assuming DIMMs with identical capacities.

Memory Frequency	DIMMs per Channel	Max. Memory Capacity	5600 Series	5500 Series
1333MHz	2 (12 DIMMs)	192GB RDIMM	X5650, L5640, E5645 and above	N/A
1066MHz	3 (18 DIMMs)	288GB RDIMM	All	N/A
800MHz	3 (18 DIMMs)	288GB RDIMM	N/A	E5503/E5507
800MHz-1333MHz (Mirroring)	2 (12 DIMMs)	96GB RDIMM	All processors	All processors

A memory rank is simply a segment of memory that is addressed by a specific address bit. DIMMs typically have 1, 2 or 4 memory ranks, as indicated by their size designation.

A typical memory DIMM description is **2GB 2Rx8 DIMM**:

- The 4R designator is the rank count for this particular DIMM (R for rank = 2)
- The x8 designator is the data width of the rank

It is important to ensure that DIMMs with appropriate number of ranks are populated in each channel for optimal performance. Whenever possible, **it is recommended to use dual-rank DIMMs** in the system. Dual-rank DIMMs offer better interleaving and hence better performance than single-rank DIMMs. For instance, a system populated with six 2GB *dual*-rank DIMMs outperforms a system populated with six 2GB *single*-rank DIMMs by **7%** for SPECjbb2005. Dual-rank DIMMs are also better than quad-rank DIMMs because **quad-rank DIMMs will cause the memory speed to be down-clocked**.

Another important guideline is to populate equivalent ranks per channel. For instance, **mixing one single-rank DIMM and one dual-rank DIMM in a channel should be avoided**.

Note: It is important to ensure that all three memory channels in each processor are populated. The relative memory bandwidth decreases as the number of channels populated decreases. This is because the bandwidth of all the memory channels is utilized to support the capability of the processor. So, as the channels are decreased, the burden to support the requisite bandwidth is increased on the remaining channels, causing them to become a bottleneck.

For peak performance:

- Always populate both processors with equal amounts of memory to ensure a balanced NUMA system.
- Always populate all 3 memory channels on each processor with equal memory capacity.
- Populate an even number of ranks per channel.
- Use dual-rank DIMMs whenever appropriate.
- For optimal **1333MHz** performance, populate with **12** dual-rank DIMMs (3 per processor, 2 per channel) for processsors that support 2 DIMMs per Channel (2DPC).
- For optimal **1066MHz** performance, populate with **12** dual-rank DIMMs (6 per processor, 2 per channel).
- For optimal **800MHz** performance with high DIMM counts, populate with **18** dual-rank or quad-rank DIMMs (9 per processor) and clock memory down to 800MHz in BIOS.
- With the above rules, it is not possible to have a performance-optimized system with 4GB, 8GB, 16GB, or 128GB. With 3 memory channels and interleaving rules, configure systems

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with 6GB, 12GB, 18GB, 24GB, 48GB, 72GB, 96GB, etc., for optimized performance.

Power guidelines:

- Fewer larger DIMMs (for example, 6 x 4GB DIMMs vs. 12 x 2GB DIMMs) will generally have lower power requirements
- x8 DIMMs (x8 data width of rank) will generally draw less power than equivalently sized x4 DIMMs

Reliability guidelines:

- Using fewer, larger DIMMs (for example 6 x 4 GB DIMMs vs. 12 x 2GB DIMMs) is generally more reliable
- Xeon 5600 series and 5500 series memory controllers support IBM Chipkill memory protection technology with x4 DIMMs (x4 data width of rank), but not with x8 DIMMs

For increased availability, the HS22V offers two additional levels of IBM Active Memory protection: **memory mirroring** and **memory sparing**.

Memory mirroring works much like disk mirroring. The total memory is divided into two channels. Data is *written concurrently to both channels*. (The third channel is unused.) If a DIMM fails in one of the DIMMs in the primary channel, it is instantly disabled and the mirrored (backup) memory in the other channel becomes active (primary) until the failing DIMM is replaced. With mirroring enabled, one-third of total memory (6 DIMMs) is available for use. (***Note:*** Due to the double writes to memory, performance is affected.) Mirroring is handled at the hardware level; no operating system support is required.

In *memory sparing*, one of the three memory channels (Ch2) for each processor is reserved as a spare for the other two channels (Ch0 and Ch1). This means that unlike mirroring (where one third of the memory is reserved for redundancy and one-third is unused), with sparing only one-third is reserved, leaving two-thirds (12 DIMMs) available as usable memory. ***Note:*** Although DIMMs within a channel do not have to be identical, the DIMMs in each of the three channels must be identical to the other channels regarding capacity and organization. (In other words, if the DIMMs in Ch0 are 2GB 2Rx4, 8GB 1Rx8, and 4GB 2Rx4, respectively (all 1.35V), then the DIMMs in Ch1 and CH2 must also be 2GB 2Rx4, 8GB 1Rx8, and 4GB 2Rx4 (all 1.35V), in that order.)

DDR3 memory is available in **1GB**, **2GB**, **4GB**, **8GB**, and **16GB** DIMMs. DIMMs are installed individually by processor. In other words, individually in a 1-processor system, or in pairs for a 2-processor system.

Integrated Virtualization

All models of the HS22V support a **USB 2.0 Flash Key** installed preloaded with **VMware vSphere Hypervisor** (formerly ESXi). Rather than management through a Service Console based on a Linux operating system, vSphere Hypervisor relies on aggregate management tools, including VirtualCenter, the Remote Command Line interface and the introduction of CIM for standards-based and agentless hardware monitoring.

vSphere Hypervisor includes all the performance, scalability and compatibility features of a hypervisor installed on disk, including full **VMFS** support across FC SAN, iSCSI SAN, and NAS, and **4-way VSMP**. Because it runs from flash memory, it's extremely fast and ideal for diskless configurations. It also offers enhanced security, because it runs without an operating system-based console and is updated/patched much like firmware.

High-Performance Adapter Slots

The HS22V blade server includes **two PCIe** adapter slots. They support **CFF** (compact form factor) cards: one standard-speed **CIOv** and one high-speed **CFFh**.

The **BladeCenter PCI Express I/O Expansion Unit 3** (BPE3) adds **2 standard full-height/full-length x16** physical/**x8** electrical (**4GBps**) **PCIe Gen 1** expansion card slots, supporting adapters of up to **25W** apiece to an HS22V. One BPE3 can be connected per HS22V blade, for a total of **3** available slots (**1** in the blade and **2** in the expansion unit). ***Note:*** The BPE3 reserves the high-speed CFFh expansion connector in the HS22V, leaving only the CIOv slot available.

Similarly, the optional **BladeCenter PCI Express Gen 2 Expansion Blade 4** (BPE4) adds **2 standard full-height/two-third-length x16** physical/**x16** electrical (**16GBps**) **PCIe Gen 2** expansion card slots. These slots are capable of supporting two high-performance graphics processing units (**GPUs**) of up to **75W** apiece, for tremendous graphics processing performance. Up to **4** of these expansion units can be attached to a single blade server (creating a 150mm 5-wide server), for a total of **10** available slots (**2** in the blade and **2** each in the expansion units; maximum 2 GPUs). ***Note:*** The BPE4 does *not* reserve the high-speed CFFh expansion connector in the HS22V, leaving both slots available in the server.

If I/O slots are a greater need than processors or memory, attaching multiple BPE4 I/O

expansion units to one blade server is much more cost-effective than installing multiple blade servers for the same number of adapter slots. (***Note:*** A maximum of *one* CFFh card is supported.)

In addition to GPUs, other adapters up to 75W can be used to connect to BladeCenter switch modules, including Fibre Channel, additional Gigabit Ethernet modules, 10Gb Ethernet, Converged Network Adapters (CNAs), InfiniBand, SAS, etc.

Disk Controllers

All HS22V models include an integrated **LSI 1064E SAS/SATA** controller. This controller supports up to **two** internal **SAS** or **SATA** HDDs or **two** internal **solid-state drives** and offers *hardware* **RAID-0/1/1E** support. (RAID-1E requires 3 or more drives.) **256MB** of optional battery-backed cache memory is available.

An optional **ServeRAID-MR10ie** controller (CIOv form-factor) adds **RAID-5/50/6/60** support for direct-attach **BladeCenter S** storage or external IBM **System Storage** EXP700, EXP710, or EXP3000, along with **256MB** of cache memory and battery backup.

These controllers provide data transfer speeds of up to **3Gb** per second[6] in *each* direction (**full-duplex**) across the SAS bus, for an aggregate speed of **6Gbps** (**600MBps**). The serial design of the SAS bus allows maximum performance to be maintained as additional drives are added.

High Performance/High-Availability Internal Storage

The HS22V supports up to **two fixed 1.8-inch solid-state** drives (SSDs) internally:

- **SATA-based solid-state** — **50GB** capacity (**100GB** maximum)
  - **High I/O Performance**
    - Offers up to 8X more IOPS than HDDs (67/33% read/write OLTP transaction base mix);
    - Optimized for heavy mix of read and write operations, such as transaction processing, media streaming, surveillance, file copy, logging, backup / recovery, and business Intelligence
  - **Lower-Cost IOPS Performance**
    - Yields better $/IOPS: lower capacity (GB) required to achieve higher IOPS
    - Consumes less energy and produces less heat than a conventional disk drive
  - **Superior Uptime**
    - 3X the reliability of mechanical disk drives[7]
    - No moving parts to fail
    - Enterprise wear-leveling to extend life even further
  - **Full OS Support**
    - Supports all ServerProven OSes

Due to the statistically higher failure rates for traditional spinning media, IBM recommends the use of the solid state drives (SSDs) as an alternative. They store data on flash memory chips, rather than on magnetic media. Like HDDs, SSDs can be used as boot media and for random access storage. However, SSDs offer higher thresholds of shock and vibration, and a higher operating temperature range (between 0 and 70 degrees C). This yields a failure rate only one-third that of HDDs (approximately 3,000,000 hours MTBF vs. 1,000,000 hours). In addition, the **IBM 50GB 1.8" Solid State Drive** requires only **2W**. This reduces the storage power requirement and heat output by as much as **80%**, compared to 2.5-inch HDDs. If used as a boot device, no special device drivers are required. Additional storage is available via the BladeCenter S chassis.

High IOPS SSD PCIe Adapters

- IBM **160GB** High IOPS **SS** Class SSD PCIe Adapter (**x4 Gen 1**—100K IOPS, 750MBps)
- IBM **320GB** High IOPS **SS** Class SSD PCIe Adapter (**x4 Gen 1**—100K IOPS, 750MBps)
- IBM **320GB** High IOPS **MS** Class SSD PCIe Adapter (**x4 Gen** 1—100K IOPS, 750MBps)
- IBM **320GB** High IOPS **SD** Class SSD PCIe Adapter (**x8 Gen 2**—**200K** IOPS, **1.5GBps**)
- IBM **640GB** High IOPS **MLC** Duo Adapter (**x8 Gen** 2—**200K** IOPS, **1.5GBps**)

For read-intensive transactional workloads requiring extreme IOPS performance, such as database, video-on-demand, and caching, IBM offers **High IOPS SSD PCIe Adapters**, equivalent to the IOPS output of approximately **500**[8] 3.5-inch 600GB 15K SAS HDDs, with **99% lower latency** (30 µs), and **7.7x** the bandwidth of a HDD. On a performance-per-watt basis, these adapters outperform HDDs by up to **445x**[9].

Because these adapters go in PCIe slots, rather than drive bays, they can be used *in addition* to

[6] Data transfer rates depend on many factors and are often less than the maximum possible.

standard HDDs and SSDs. This makes them ideal for virtualized servers running multiple tasks, requiring both write- and read-intensive storage media. As flash media they also offer a predictable lifetime, compared to the sporadic failure rate of HDDs, using N+1 chip-level redundancy and 11-bit ECC protection.

Note: The High IOPS Adapters require a BPE4 expansion unit.

If you need more storage space, terabyte capacities are possible with optional external direct-attach, NAS, and SAN storage solutions.

External Tape Storage

The HS22V supports various external rack-mounted SAN-attached tape drives. Supported tape technologies include:

- IBM System Storage TS2230 Express Tape Drive
- IBM System Storage TS2240 Tape Drive Model S4E
- IBM System Storage TS2900 Tape Autoloader
- IBM System Storage TS3100 Tape Library
- IBM System Storage TS3200 Tape Library
- IBM System Storage TS3310 Modular Tape Library
- IBM System Storage TS3500 Tape Library

Gigabit Ethernet Controller

The HS22V includes a **dual-port** integrated **Broadcom BCM5709S** Gigabit Ethernet controller for up to 10X higher maximum throughput than a 10/100 Ethernet controller. The controller offers **TOE** (TCP Offload Engine) support, as well as **failover** and **load balancing** for better throughput and system availability. It also supports highly secure remote power management using **IPMI 2.0**, plus Wake on LAN® and PXE (Preboot Execution Environment) Flash interface.

If **2** ports aren't enough, optional **2-port** or **4-port Ethernet** expansion cards can be used for additional ports. For example, the **CIOv** slot can hold a **2-port** card and the **CFFh** slot supports a **4-port** card, for a total of **8** Gigabit Ethernet ports per HS22V blade. Using **BladeCenter Virtual Fabric** increases the number of available ports to **12**.

Light Path Diagnostics

Light path diagnostics enables a technician to quickly identify and locate a failed or failing system component, such as a specific blower module or memory DIMM. This enables quick replacement of the component, which helps increase server uptime and lower servicing costs.

The front of each blade server—and the chassis itself—has an LED indicator light to show possible component failures. This lets the servicer identify the failing component without the need to or remove the blade server from the chassis. The light path diagnostics panel tells the servicer which component of the affected server requires attention.

In addition, many components have their own identifying LEDs. For example, each of the memory modules has an LED next to the socket, as do both processors. This allows the servicer to easily identify exactly which component needs servicing. By following the "light path," the component can be replaced quickly, and without guesswork. (***Note:*** In the event of a failed DIMM, the system will restart and mark the DIMM as bad while offline, thus allowing the system to continue running, with reduced memory capacity, until serviced.)

BladeCenter Chassis

IBM's blade architecture offers ***five** choices* of compatible and interoperable chassis in which to use various blade servers. Each chassis serves different customer needs. The new **BladeCenter S** is a small, entry-level chassis designed for office environments. The original **BladeCenter E** chassis (refreshed with the latest Advanced Management Modules and power supply modules) offers maximum density, great flexibility and a wide variety of expansion options at an entry-level price. The next-generation **BladeCenter H** chassis offers all of BladeCenter's capabilities, and adds high-performance features, including 10Gb fabric support. If you need a **ruggedized**

[7] MTBF of 73GB 2.5-inch 10K RPM HDD for the first 12 months = 305,167. MTBF of solid-state SanDisk SDD SATA 5000 2.5-inch 16GB = 918,298.

[8] According to internal IBM testing, the typical **maximum IOPS** of a 600GB 15K **3.5**-inch hot-swap SAS HDD is ~**400** (4K random reads), while the typical IOPS of a 640GB High IOPS SSD PCIe adapter is ~**200,000**, or ~**500x**. The typical **bandwidth** of the same HDD = ~**195MBps** (64K sequential reads), while the typical bandwidth of a 640GB High IOPS MLC adapter is ~**1.5GBps**, or ~**7.7x**.

[9] 97,014 IOPS / 9W = **10,779 IOPS** per watt (160GB/320GB adapters). 196,000 IOPS / 12W = ~**16,333 IOPS** per watt (640GB adapters). 400 IOPS / 16.5W = ~**24 IOPS** per watt (600GB 15K 3.5-inch hot-swap SAS HDD).

chassis (for example, government/military or telecom), **BladeCenter T** offers special features optimized for those environments. *(HS22V is not supported in the BladeCenter T.)* The next-generation **BladeCenter HT** is a high-performance **ruggedized** telecommunications platform, also supporting 10Gb fabrics. There is a high degree of interchangeability and compatibility of features among the chassis. All of these chassis can be installed in a rack along with other rack-optimized equipment. See the separate *BladeCenter Chassis Sales Guide* for details.

Hot-Swap/Redundant Components

System availability is maximized through the extensive use of hot-swap and redundant components, both in the blade server and in the various BladeCenter chassis, including:

- **Redundant memory protection** (with **Chipkill** error correction and **memory mirroring** or **memory sparing** enabled)
- **Hot-swap, redundant hard disk drives** (in **BladeCenter S**) and **solid-state drives** (with **RAID** protection)
- **Hot-swap, redundant power supply modules**
- **Hot-swap, redundant cooling fan/blower modules**
- **Hot-swap, redundant switch modules**
- **Redundant midplane connectors** between blades and modules

Energy-Smart Features

IBM servers work hard to keep your energy bills low—from high-efficiency power supplies and fans to lower-draw processors and memory. Technologies such as these, along with the Xeon 5500/5600 series processors that intelligently adjust their voltage and frequency, help take costs out of IT:

- **40W 4-core processors** use **50%** less energy than 80W processors and **69%** less than 130W processors.
- **60W 6-core processors** use **37%** less energy than 95W processors and **54%** less than 130W processors.
- **1.5V DDR3 DIMMs** consume **10-15%** less energy than 1.8V DDR2 DIMMs used in older servers.
- **1.35V DDR3 DIMMs** consume up to **19%** less energy than 1.5V DDR3 DIMMs.
- **Solid-State Drives** consume up to **80%** less energy than 2.5-inch HDDs and up to **88%** less than 3.5-inch HDDs.
- Operating at as much as **94%** efficiency, **high efficiency power supplies** use less energy than competitive power supplies that average only **70-80%** efficiency, and produce less waste heat that needs to be cooled.
- **Dynamic fan speeds** — In the event of a fan failure, the other fans will run faster to compensate until the failing fan is replaced. Competitive fans must run faster at all times, just in case, wasting power.

Extensive System Support Features

The IBM services and technical support portfolio provides world-class, consistent, high-quality service and support. From the start, IBM programs make it easier for you to plan for, configure and purchase BladeCenter servers, get them running and keep them running long-term. These features include IBM ServerProven, IBM Standalone Solutions Configuration Tool, IBM System x and BladeCenter Power Configurator, IBM ServerGuide, IBM Systems Director Service and Support Manager, Product Customization er-Services and extensive technical support offerings.

The IBM **ServerProven** program provides the confidence that specific options and operating systems have been tested on the blade servers and chassis and are officially supported to work together. It is updated frequently to keep the latest compatibility information at your fingertips.

The IBM **Standalone Solutions Configuration Tool** (SSCT) is a downloadable tool that simplifies the often complex chore of configuring a full rack of servers (including blade servers) and confirming that you have all the cables, power distribution units, KVM (keyboard, video and mouse) switch boxes and other components you need, as well as the proper airflow clearances, electrical circuits and other environmental conditions.

IBM **System x and BladeCenter Power Configurator** helps IT managers plan for data center power needs, by providing the following information for specific configurations of System x and BladeCenter systems: *power input* (watts), *PDU sizing* (amps), *heat output* (BTUs), *airflow requirements through chassis* (CFM), *VA rating, leakage current* (mA), and *peak inrush current* (amps).

IBM **ServerGuide** (installed from CD) simplifies the process of installing and configuring System x servers. ServerGuide goes beyond mere hardware configuration by assisting with the automated installation of the Microsoft® Windows® Server 2008 operating system, device drivers

and other system components, with minimal user intervention. (Drivers are also included for support of Novell NetWare, Red Hat Linux and SUSE LINUX.) This focus on deployment helps to reduce both your total cost of ownership and the complexity that administrators and technical personnel face.

IBM Systems Director Service and Support Manager (previously called IBM Electronic Service Agent™) is an innovative "call home" feature that allows System x and BladeCenter servers to automatically report hardware problems to IBM support, which can even dispatch onsite service[10] if necessary to those customers entitled to onsite support under the terms of their warranty or an IBM Maintenance Agreement. Service and Support Manager resides on a server and provides electronic support and problem management capabilities through a highly secure electronic dialogue between your systems and IBM. It monitors networked servers for hardware errors and it can perform hardware and software inventories and report inventory changes to IBM. All information sent to IBM is stored in a highly secure database and used for improved problem determination.

Additional services include hardware warranty upgrades and factory-installed **Product Customization Services** (PCS), such as asset tagging, hardware integration, software imaging and operating systems personalization.

IBM offers extensive **technical support** by phone and via the Web. Support options include links to forums/newsgroups, problem submission, online shopping support, service offerings, device drivers for all IBM product lines, software downloads and even upcoming technical seminar worldwide schedules and registration. Also available are remote installation, configuration and usage support for both System x hardware and software, as well as onsite custom services to provide the level of expertise you require.

IBM Maintenance and Technical Support solutions can help you get the most out of your IT investment by reducing support costs, increasing availability and simplifying management with integrated support for your multiproduct, multivendor hardware and software environment. For more information on hardware maintenance, software support, solution support and managed support, visit http://**ibm.com**/services/maintenance.

Advanced Systems Management Capabilities

Each BladeCenter chassis offers a high level of systems management capabilities that are well-suited to remote locations as well as to stand-alone environments. Features include the Advanced Management Module (AMM), Integrated Management Module (IMM), IBM ToolsCenter, Automatic Server Restart, Systems Director Active Energy Manager, Wake on LAN® support, PXE 2.0 support, text and graphics console redirect, Predictive Failure Analysis, Embedded Dynamic System Analysis, and IBM Systems Director.

The chassis-based **AMM**, in combination with the HS22V blade server's **IMM**, provides industry-standard **Intelligent Platform Management Interface** (**IPMI**) **2.0**-compliant systems management. The AMM provides a number of important system functions, including:

- Monitoring of system and battery voltage, system temperature, fans, power supplies, processor and DIMM status
- Fan speed control
- Product ID and Family ID detection
- Highly secure remote power on/off
- System reset control
- NMI/SMI detection and generation
- System diagnostic LED control (power, HDD, activity, alerts, heartbeat)
- IPMI over LAN
- Serial Over LAN
- Proxy server support
- LAN messaging and alerting
- VLAN support
- Enhanced authentication and encryption algorithms (RMCP+, AES)
- Local update of IMM firmware
- Firmware firewall
- Support for IPMI v2.0 compliant management software (e.g., xCAT)
- Other mandatory and optional IPMI functions in the blade's IMM

The IMM, via the management module, alerts IBM Systems Director to anomalous environmental

[10] For onsite labor, IBM will attempt to diagnose and resolve the problem remotely before sending a technician.

factors, such as voltage and thermal conditions—even if the server has failed.

Other systems management features offered for the combination of blade server and chassis include:

- Predictive Failure Analysis for system processors, memory and HDDs, as well as chassis switch modules, blower modules and power modules
- Web-based out-of-band control
- Latest OS failure screen capture
- Remote virtual media
- High-speed remote redirection of PCI video, keyboard and mouse
- SSL (Secure Socket Layer) and LDAP (Lightweight Directory Access Protocol) support

In order to put control of processor power-saving features at the fingertips of administrators, IBM developed **IBM Systems Director Active Energy Manager**. Active Energy Manager is designed to take advantage of new processor features, such as balancing the performance of the system according to available power input. It provides the ability to plan and predict power consumption based on your BladeCenter hardware configuration. It also helps you reduce the infrastructure required for redundancy, by using fewer servers on smaller power feeds and potentially lowering your overall data center support costs. It does this by inventorying all components at the blade level, then adding up the power draw for each blade and tracking that usage. In failure mode, Active Energy Manager (through the BladeCenter Management Module) might request that certain blades in each domain throttle down to reduce power consumption.

IBM **ToolsCenter** consolidates 42 needed tools for managing servers individually into an integrated suite of 8 tools. They are organized by function: deployment, updates, configuration and diagnostics. Tools are now simpler to access and use with a single webpage for access, a common look and feel and a common command line interface for the scripting tools. The ToolsCenter **Bootable Media Creator** offers significantly more functionality than past tools with the ability to add more tools to the bootable image and to automatically download the bootable environment if needed. Bootable Media Creator allows you to create bootable CDs, DVD, and USB keys for updates customized to your systems.

Automatic Server Restart (ASR) helps reduce downtime by restarting the server automatically in the event of a system lockup. ASR technology is a combination of hardware circuitry tied into the server's system reset function and a device driver. As long as the server continues running, the ASR watchdog timer will keep being reset, but if the operating system crashes or the hardware freezes somehow the ASR software will be unable to reset the hardware timer. If the timer is not reset within five minutes, it automatically triggers the ASR hardware, which immediately restarts the server (and logs an ASR event with IBM Systems Director). These features are designed so that *no more than five minutes can pass before the server is restarted*.

Text and Graphics Console Redirect support allows the administrator to remotely view HS22V text and graphics messages over serial or LAN.

Wake on LAN permits the server to be remotely powered on if it has been shut off. Once powered up, the server can be controlled across the network, using the **Preboot Execution Environment** (PXE).

Like Wake on LAN, **PXE** is system firmware. It allows software such as the **IBM Remote Deployment Manager** to take control of a system before the BIOS, operating system or applications are loaded (using Wake on LAN/PXE) and lets an administrator perform many low-level tasks remotely that would otherwise require a visit to each system. These tasks may include such things as formatting a hard disk drive, updating system firmware, or deploying a Windows or Linux operating system.

Predictive Failure Analysis (PFA) enables the AMM and the IMM to detect impending failure of supported components (processors; memory; expansion cards; switch, blower and power supplies; and hard disk drives) before actual failure, and alert the administrator through IBM Systems Director. This gives you the ability to replace the failing component *before* it fails, resulting in increased uptime.

Embedded Dynamic System Analysis (DSA) feature collects and analyzes system information to aid in diagnosing problems. The diagnostic programs collect the following information:

- System configuration
- Network interfaces and settings
- Installed hardware
- Service processor status and configuration
- Vital product data, firmware, and BIOS configuration
- Hard disk drive health
- RAID controller configuration
- Event logs for ServeRAID controllers and service processors

The diagnostic programs create a merged log that includes events from all collected logs. The information is collected into a file that you can send to IBM service and support. Additionally, you can view the information locally through a generated text report file, or you can copy the log to removable media and view the log from a Web browser.

IBM Systems Director software for advanced workgroup management is included with the server. IBM Systems Director comes with a portfolio of tools, including *Active Energy Manager, Service and Support Manager*, and other tools. *System Availability* (a no-charge download) and *Capacity Manager* (sold separately) are available as add-ons for additional server management and increased availability. IBM Systems Director provides a single uniform graphical interface for all of these systems management functions.

IBM Systems Director enables you to customize thresholds and monitor system components (for things like temperature, voltage regulation, etc.) to help maximize uptime.

Key Options

IBM options for System x servers let you take your servers to a higher level

You rely on System x and blade options to supply a comprehensive solution for your business needs. Options help create an optimized server system to meet your data protection, storage and availability needs. Every IBM option is designed and tested for peak performance and flexibility, helping to maximize your return on investment. The combination of System x servers and options lets you keep your fingers on the pulse of your e-business.

Processors — The Intel Xeon processor provides high clock rates, 64-bit extensions, a large cache, Hyper Threading Technology, Turbo Boost Technology, energy-saving features, and advanced features for availability and manageability. Large cache size and multiple cores, combined with an **800MHz**, **1066MHz** or **1333MHz** memory access speed, reduce memory latency and facilitate the movement of data through the processor and I/O devices. (***Note:*** System performance depends not only on the number of processors in the server but also on the power and functionality of each processor, as well as the number, capacity, and arrangement of the DIMMs.) Adding a second processor may be a cost-effective way to achieve significant performance improvements.

Memory — Memory is a significant factor in systems application performance. Adding more memory to a BladeCenter server is one of the most effective ways to increase application performance. For best performance in a server with a four-core processor, there should be twice as much memory available as for a two-core processor. ***Note:*** Fewer large-capacity DIMMs may provide better performance and use less energy than more lower-capacity DIMMs. On the other hand, more lower-capacity DIMMs can be less expensive to buy than fewer high-capacity DIMMs.

I/O Expansion Units — A choice of BladeCenter **PCI Express Expansion Unit 3** (**BPE3**) or BladeCenter **PCI Express Gen 2 Expansion Blade 4** (**BPE4**) offers from **3** to **10** total adapter slots, to support additional fabrics (including Ethernet, 10Gb Ethernet, Fibre Channel, SAS, and Converged network Adapters), and high-performance graphics processing units (GPUs).

Solid-State Drives — IBM offers a **50.0GB** 1.8-inch **solid-state drive** as a higher reliability, lower-energy-use alternative to HDDs. They can be used as a highly available boot drive, for storing disk images, or for other uses that stress read performance. Additional direct-attach storage is available via the BladeCenter S chassis.

High IOPS SSD PCIe Adapters — For storage media offering up to **500 times** the I/O operations per second (IOPS) and up to **7.7 times** the bandwidth of 15,000-RPM HDDs, IBM offers the **160GB High IOPS SS Class SSD PCIe Adapter**, the **320GB High IOPS SS Class SSD PCIe Adapter**, the **320GB High IOPS MS Class SSD PCIe Adapter,** and the **320GB High IOPS SD Class SSD PCIe Adapter**, as well as the **640GB High IOPS MLC Duo Adapter**. These adapters offer near-DRAM performance, with extremely high data retention (up to 25 years) and RAID-grade data protection, with **160GB** or **320GB** capacities.

ServeRAID Controllers — System x servers using ServeRAID technology allow organizations to build a reliable foundation for business-critical computing. IBM ServeRAID technology allows an array consisting of multiple physical hard disk drives to be treated as one logical drive. ServeRAID technology also allows data to be stored redundantly, across multiple hard disk drives— enhancing both the integrity and the availability of the data. SAS and SATA ServeRAID controllers offer enhanced performance due to onboard processors and cache. Because IBM ServeRAID controllers can help significantly improve data transfer rates, this technology is extremely effective when implementing demanding, transaction-oriented applications. By employing the advanced fault tolerance of IBM ServeRAID technology, companies can effectively implement networked business systems that require large amounts of storage space for data and applications that must be available for their businesses to continue operating.

The optional **ServeRAID-MR10ie** controller (CIOv form-factor), with up to **6Gbps** throughput per SAS port, adds **RAID-5**/**50**/**6**/**60** support and **256MB** of cache memory and battery backup, as well as support for direct-attach **BladeCenter S** storage or external **System Storage** expansion

units.

I/O Slots — The HS22V supports the addition of a **PCIe I/O Expansion Unit 3**, which provides **3** additional PCIe slots.

External Storage — The IBM **System Storage DS3000, DS4000, DS5000**, and **DS8000** series, as well as the **System Storage N3000, N5000, N6000**, and **N7000** series, comprise a powerful and broad shared storage family with integrated management software designed to meet midrange and enterprise needs. For lower-end needs, IBM offers the System Storage **EXP810** and **EXP3000** storage expansion units.

Additionally, external LAN-attached tape storage is available.

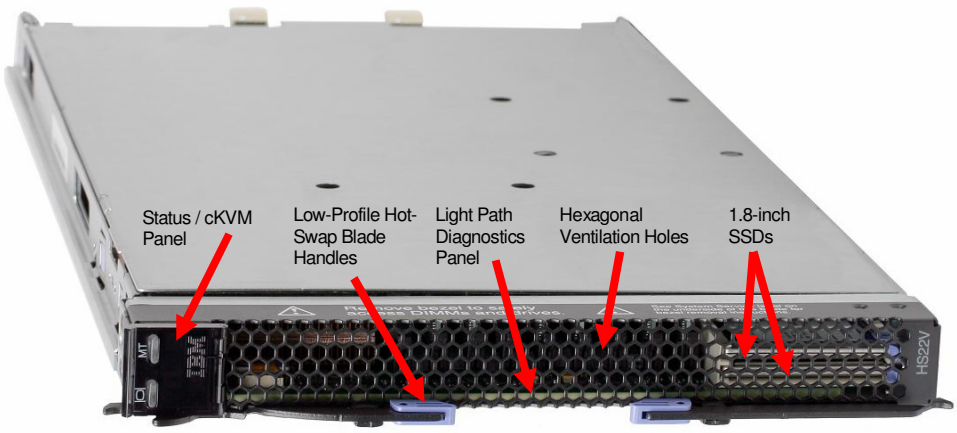
Communication Modules — The various BladeCenter chassis support integrated communication and I/O switches and/or bridges for **Gigabit** and **10Gb Ethernet**, **Myricom**, **4Gb** and **8Gb Fibre Channel**, **1X** and **4X InfiniBand**, **iSCSI**, **3Gb SAS**, and others. Expansion adapters for individual HS22V blades are available to interface with these modules. The BladeCenter H and BladeCenter HT also support the **Multi-Switch Interconnect Module**, which doubles the number of Gigabit Ethernet and Fibre Channel connections available to all blades in the chassis.

Rear Door Heat eXchanger — The unit attaches to the back of an IBM S2 42U Enterprise Rack. It is capable of removing up to 50,000 BTUs (14KVa) from the data center using water lines under the raised floor. The door swings open for servicing.

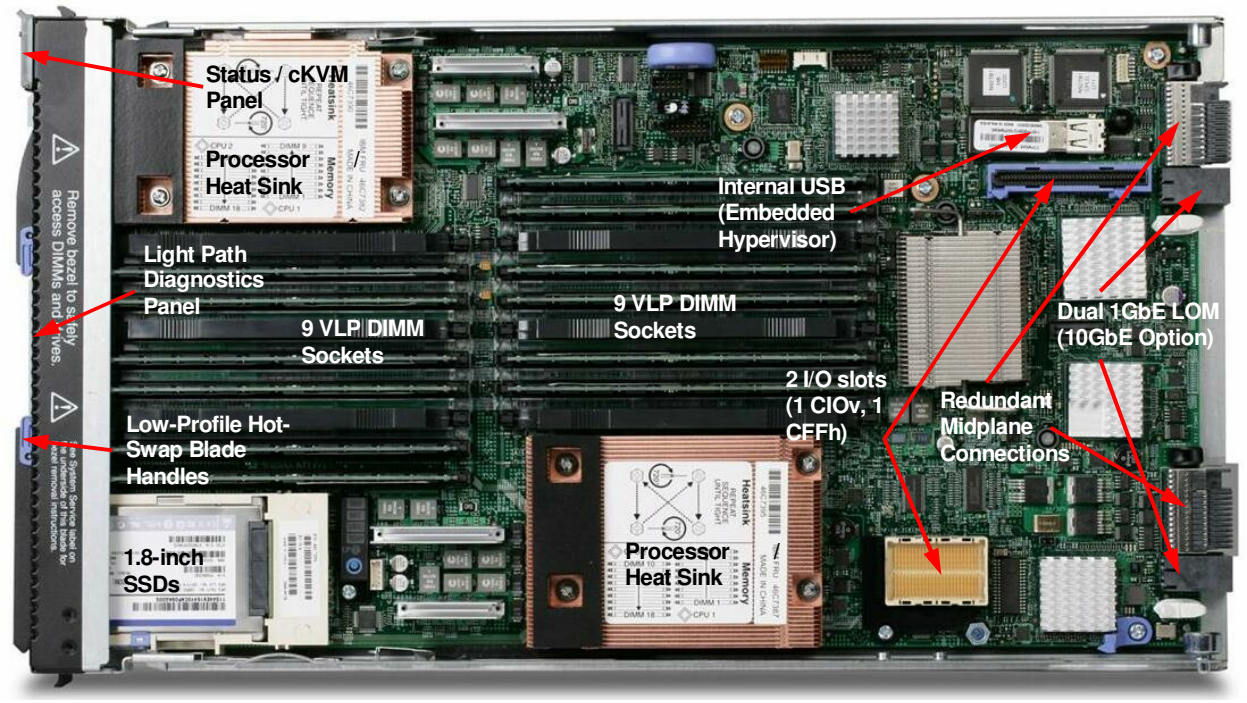
Redundant features — Optional hot-swap drives, power supply modules, blower modules, management modules, switches and bridges provide redundancy for the various BladeCenter chassis.

HS22V Images

Front View



Interior View



BladeCenter HS22V Specifications					
Machine type	**7871- Axx, Bxx, Cxx, Dxx, Fxx, Gxx, Hxx, Nxx** (plus CTO and special bid)				
Form factor	30mm blade				
Processor type	**Six-core Xeon (E56xx/L56xx/X56xx) 2.0GHz** L5630 (CTO), **2.26GHz** L5640 (N2x), **2.4GHz** E5645 (CTO), **2.53GHz** E5649 (B6x), **2.66GHz** X5650 (H2x/HAx), **2.93GHz** X5670 (H4x), **3.06GHz** x5675 (C6x), **3.33GHz** X5680 (F2x), **3.46GHz** X5677 (F3x), **3.46GHz** X5690 (C8x)		**Four-core Xeon (E56xx/L56xx/X56xx) 1.6GHz** E5603 (A5x), **1.86GHz** L5609 (CTO), **1.86GHz** L5618 (spec bid), **2.13GHz** E5606 (CTO), **2.26GHz** E5607 (A7x), **2.40GHz** E5620 (G2x), **2.66GHz** E5640 (G4x/ GDx), **2.93GHz** X5647 (B5x), **3.06GHz** X5667 (H5x), **3.2GHz** X5672 (C5x), **3.6GHz** X5687 (C7x)	**Four-core Xeon (E55xx) 2.26GHz** E5507 (A4x)	**Two-core Xeon (E55xx) 2.00GHz** E5503 (D3x)
Processor power draw	**130W** (B5x, C7x/C8x, F2x/F3x)	**95W** (C5x/C6x, H2x/H4x/ H5x/HAx)	**80W** (A4x/A5x/A7x, B6x, D3x, G2x/ G4x/GCx, plus E5606/E5645 via CTO)	**60W** (N2x, plus L5630 via CTO)	**40W** (L5609. L5618 via CTO)
Internal L3 cache	**12MB** shared cache (A5x/A7x, B5x/B6x, C5x/C6x/C7x/C8x, F2x/F3x, G2x/G4x/GCx, H2x/H4x/H5x/HAx, N2x, plus E5645, L5609/L5618/L5630,via CTO)			**4MB** shared cache (A4x/A5x/A7x, D3x, plus E5606 via CTO)	
QuickPath Interconnect (QPI) speed (gigatransfers per second)	**6.4 GTps** (B6x, C5x/C6x/ C7x/C8x, F2x/F3x,		**5.86 GTps** (A5x/A7x, B5x, G2x/G4x/GDx, N2x, plus	**4.8 GTps** (A4x/A5x/A7x, D3x, plus E5606 via CTO)	

BladeCenter HS22V Specifications				
	H2x/H4x/H5x/HAx)	E5606/E5645, L5630 via CTO)		
Maximum memory access speed	**1333MHz** (F2x/F3x, H2x/H4x/H5x/HAx, N2x, plus E5645, L5630 via CTO)	**1066MHz** (A5x/A7x, B5x, G2x/G4x/GCx, plus E5606, L5609/L5618 via CTO)	**800MHz** (A4x/A5x/A7x, D3x, plus E5606 via CTO)	
# of processors standard / maximum	1 / 2			
NEBS/ETSI Compliance	Select blades are NEBS3/ETSI-compliant. (Contact IBM sales for details.)			
Chipset	Intel 5520			
Standard / maximum memory[11]	**12GB** (3 x 4GB) / **288GB** (B5x/B6x, C5x/C6x/C7x/C8x)	**6GB** (3 x 2GB) / **288GB** (F2x/F3x, G2x/G4x/GDx, H2x/4x/H5x/HAx, N2x)	**4GB** (1 x 4GB) / **288GB** (A5x/A7x)	**3GB** (3 x 1GB) / **288GB** (A4x, D3x)
Standard memory type	**Registered** PC3-10600 DDR3 ECC (operating at 1333MHz, 1066MHz or 800MHz, depending on processor and memory configuration)			
Supports 1333MHz with 2 DIMMs per channel	1333MHz E56xx, L56xx, and X56xx processors support 2DPC at 1333MHz			
Memory interleaving	Yes			
DIMM capacities supported	1GB, 2GB, 4GB, 8GB, 16GB			
Chipkill protection supported	Yes (using x4 DIMMs)			
# of DIMM sockets total / available	18 / 15			
# of 1.8-inch drive bays total / available	**2 / 2**			
# of 2.5-inch drive bays total / available	None			
Maximum internal SSD capacity	**100GB** (2 x 50GB) fixed			
SSD capacities supported	**50.0GB**			
# of SSDs standard	None			
Additional Internal SSD storage via PCIe adapter	**160GB** High IOPS **SS** Class SSD PCIe Adapter **320GB** High IOPS **SS** Class SSD PCIe Adapter **320GB** High IOPS **SD** Class SSD PCIe Adapter **320GB** High IOPS **MS** Class SSD PCIe Adapter **640GB** High IOPS **MLC Duo** Adapter			
Modular Flash Drives supported	1			
Internal USB Flash Drive (optional)	**1** (preloaded with **VMware vSphere Hypervisor** (formerly ESXi))			
# of optical drives standard	None (one in BladeCenter chassis)			
# of floppy drives standard	None (one standard in BladeCenter E or BladeCenter H chassis)			
Internal tape drives supported	None (SAN-attached)			
SSD drive interface	SATA			
Integrated disk controller	LSI Logic 53C1046E			
Optional RAID controller	ServeRAID-MR10ie			

[11] Maximum memory capacity may require the replacement of standard components with the largest supported component available.

BladeCenter HS22V Specifications		
RAID levels supported	RAID-0/1 (standard)	
External disk drive support	NAS/SAN-attach	
# of PCIe slots	**2 x16** mechanical/**x8** electrical slots included (up to **3** total using **1** BladeCenter **PCI Express I/O Expansion Unit 3** (**BPE3**) blade)	**2 x16** mechanical/**x16** electrical slots included (up to **10** total using **4** BladeCenter **PCI Express Gen 2 Expansion Blade 4** (**BPE4**) blades)
# of PCI-X slots	None	
# of legacy PCI slots	None	
# of video ports	None (chassis-attached)	
Video controller	Matrox G200eV (in IMM)	
Video memory	16MB SDRAM	
Maximum video resolution at 32-bit color	**1024x768** resolution (analog), with a color depth of 32 bits at **85Hz**; **1440x90** resolution (digital), with a color depth of 32 bits at **60Hz**	
Gigabit Ethernet controllers std	**Dual-port** Broadcom **BCM5709S**—TOE-enabled	
# of Gigabit Ethernet ports	**2** (standard) / **8** (maximum); **12** with BladeCenter Virtual Fabric Adapter	
# of RS485 ports	None	
# of serial ports	None (1 direct via BladeCenter H chassis, or Serial over LAN in BladeCenter E and BladeCenter H)	
# of parallel ports	None	
# of mouse ports	None (1 via chassis)	
# of keyboard ports	None (1 via chassis)	
# of USB ports	1 (plus 2 via chassis)	
Systems management controller	Integrated Management Module	
Diagnostic LEDs (front panel)	Power good, blade location, over temperature, information, general fault	
Predictive Failure Analysis support	Processor, memory, HDDs, expansion cards	
BIOS type	UEFI 2.1	
Power supply size	Contained in chassis	
# of power supplies standard / maximum	Contained in chassis	
# of fans/blowers standard / maximum	Contained in chassis	
Dimensions (HWD) / weight	9.7” (245mm) **H** 1.14” (29mm) **W** 17.6” (446mm) **D**	12 **lbs** (maximum) 5.44 **kg** (maximum)
Operating systems supported	Microsoft Windows Server 2008 and R2 (Standard/Web/Enterprise/HPC Editions) 32/64-bit, Windows Essential Business Server 2008 (Standard/Premium Editions), Windows Small Business Server 2008 (Standard/Premium Editions), RHEL 5.3 32-bit with Xen or 64-bit—with or without Xen, RHEL AS/ES/WS/HPC 4.7 64-bit, RHEL MRG 1.0 Realtime 64-bit, SLES 11 32-bit without Xen or 64-bit with or without Xen, SLES 10 32-bit with Xen and 64-bit with or without Xen, SUSE Enterprise Real Time 10 64-bit, Sun Solaris 10, VMware vSphere Hypervisor 3.5/4.0	
Extended/long life support	Select blades are supported for long life. (Contact IBM sales for details.)	
Length of limited warranty	3 years (parts and labor) onsite	

Please see the Legal Information section for important notices and information.

The Bottom Line

The HS22V offers maximum bang for the buck by incorporating powerful features in a tiny package:

Price/Performance

- **Multi-core processors** — Up to **two 2.0** to **3.46GHz six-core** or **1.6** to **3.6GHz four-core** Xeon **5600** series processors; or **2.26GHz four-core** or **2.0GHz two-core** Xeon **5500** series processors
- **Low-voltage processors** — Up to **two 60-watt six-core** or **40-watt four-core** Xeon **5600** series processors
- **Large cache** — **Up to 12MB** of L3 processor cache (processor-specific)
- **Embedded virtualization** via optional internal flash drive
- **Fast memory access** — **1333MHz**, **1066MHz**, or **800MHz** access (depending on the processor model and DIMMs used); 1333GHz memory access even with 2 DIMMs per channel (processor-specific)
- **Fast graphics** — Up to **2 graphics processing units** (GPUs) per server (using the optional BPE4 expansion unit)
- **High-IOPS technology** — Optional **High IOPS** SSD adapters
- **Fast I/O** — **10Gb Ethernet**, **10Gb CNA**, **4X InfiniBand**, **6Gb SAS**, or **8Gb Fibre Channel** connectivity via an optional expansion card, as well as Virtual Fabric for IBM BladeCenter
- **Fast storage technology** — SSDs offer up to 8X more IOPS than HDDs
- **Fast communications** — Integrated **dual Gigabit** Ethernet, with the option for two or four additional Gigabit Ethernet ports via expansion cards and expansion unit (total **12** ports per blade); support for **10Gb Ethernet**

Flexibility

- **Single- to five-wide** configurations (blade server and up to 4 I/O expansion units)
- **Large memory capacity** — Up to **288GB** using 8GB DIMMs
- Up to **two** internal **1.8-inch non-hot-swap** SSDs; more with the **BladeCenter S chassis** or external storage
- **50GB solid-state drives** are an energy-saving, higher-reliability alternative to HDD storage
- Optional IBM **160GB, 320GB, or 640GB High IOPS SSD Adapters** for extremely high IOPS and bandwidth storage (requires BPE4 expansion unit)
- Integrated RAID — **RAID-1** mirrored arrays standard; enhanced **RAID-1E** arrays are available using a **BladeCenter S chassis**; **RAID-5** arrays are also available using an optional **ServeRAID** controller
- **Two** *available* **adapter slots** standard :
  - **Two** CFF (compact form factor) slots: one high-speed CFFh and one standard-speed CIOv
- Additional ***optional*** adapter slots[12] —
  - Up to **3** total, using **1** BladeCenter **PCI Express I/O Expansion Unit 3 (BPE3)** blade
  - Up to **10** total, using **4** BladeCenter **PCI Express Gen 2 Expansion Blade 4** (BPE4) blades

Manageability and Availability

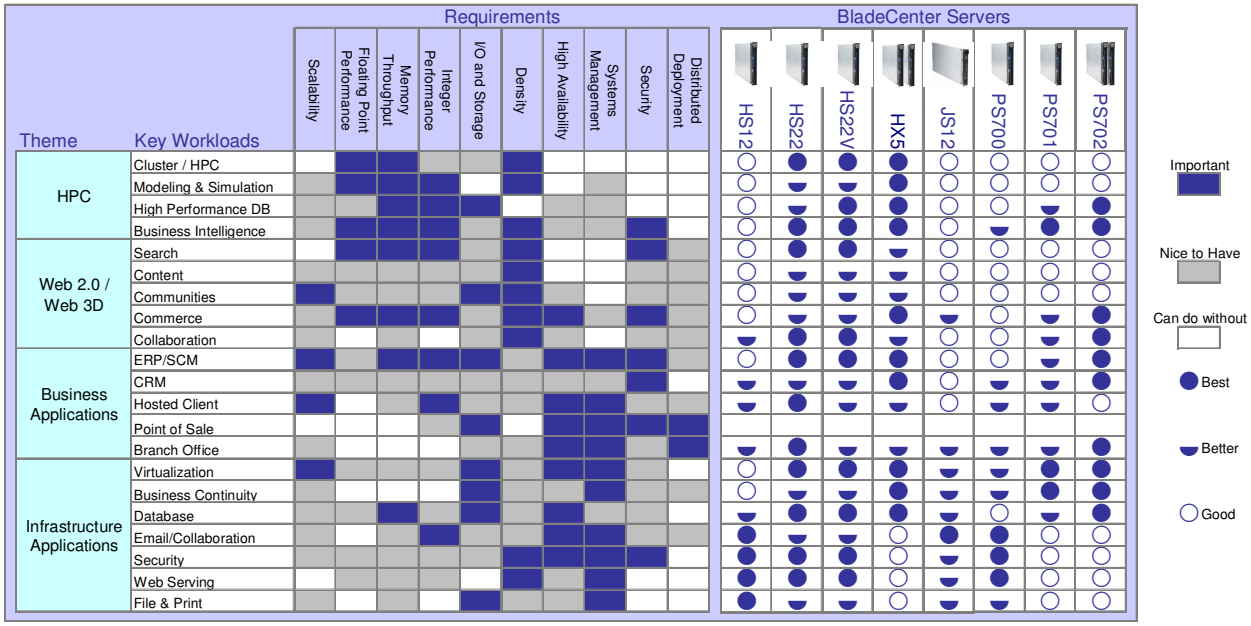
- **IBM Systems Director** systems management software, including:
  - IBM Systems Director **Active Energy Manager**
  - IBM **Service and Support Manager**
- **Integrated Management Module**:
  - **IPMI 2.0** compliance, including highly secure remote power control
  - **cKVM**
  - **Advanced management capabilities**
- Interface to one or two **Advanced Management Modules** in the chassis for advanced systems management capability
  - Supports **LDAP** and **SSL** industry standards
  - **Text and graphics console redirection** systems management
  - **Serial over LAN**
- **Active Memory protection**:
  - Advanced **Chipkill** ECC memory protection support
  - **Memory mirroring**
- Optional **solid-state drives** as a high-reliability alternative to internal storage (with up to three times the MTBF of spinning disk drives)

[12] The PCIe expansion units each require an adjacent blade slot.

- Numerous **hot-swap/redundant capabilities** provided via the chassis

Server Comparison Chart

The following table shows the suggested uses for the respective IBM BladeCenter blade servers, including comparisons of the uses for which each server is best suited:



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IBM BladeCenter Servers and Options	http://**ibm.com**/systems/bladecenter
IBM Systems Director Service and Support Manager	http://**ibm.com**/support/electronic
IBM System x and BladeCenter Power Configurator	http://**ibm.com**/systems/bladecenter/resources/powerconfig.html
IBM Standalone Solutions Configuration Tool	http://**ibm.com**/systems/x/hardware/configtools.html
IBM Configuration and Options Guide	http://**ibm.com**/systems/x/hardware/configtools.html
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Other Technical Support Resources	http://**ibm.com**/systems/support

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Dept. U2SA
3039 Cornwallis Road
Research Triangle Park, NC 27709

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Some machines are designed with a power management capability to provide customers with the maximum uptime possible for their systems. In extended thermal conditions, rather than shutdown completely, or fail, these machines automatically reduce the processor frequency to maintain acceptable thermal levels.

MB, GB and TB = 1,000,000, 1,000,000,000 and 1,000,000,000,000 bytes, respectively, when referring to storage capacity. Accessible capacity is less; up to 3GB is used in service partition. Actual storage capacity will vary based upon many factors and may be less than stated.

Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will depend on considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.

Maximum internal hard disk and memory capacities may require the replacement of any standard hard drives and/or memory and the population of all hard disk bays and memory slots with the largest currently supported drives available. When referring to variable speed CD-ROMs, CD-Rs, CD-RWs and DVDs, actual playback speed will vary and is often less than the maximum possible.

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